MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LVI. DECEMBER 13, 1895. No. 2

A. A. COMMON, LL.D., F.R.S., President, in the Chair.

Major Kingsley Foster, Shenley, Red Hill, Surrey ;
Rev. Henry A. Hall, M.A., Grammar School, Totnes, Devon;
Rhishard Llewelyn Jones, M.A., Professor of Physics, Presidency College, Madras, India ; and
Herbert Savery, M.A., Marlborough College, Wilts,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Cyril E. Ashford, M.A., Assistant Master, The School, Harrow (proposed by W. H. M. Christie) ;
Frank Arthur Bellamy, Assistant, University Observatory, Oxford (proposed by H. H. Turner) ;
Thomas Folkes Claxton, First Assistant, Royal Alfred Observatory, Mauritius (proposed by W. H. M. Christie);
Philip H. Cowell, B.A., Fellow of Trinity College, Cambridge (proposed by W. H. M. Christie) ;
Robert Fermor Rendell, B.A. (Lond.), The Glen, Blackheath Hill, S.E. (proposed by W. H. M. Christie) ;
George Albert Smith, St. Ann's Gardens, Brighton (proposed by J. H. Mitchiner) ; and
Charles Albert Taylor, 33 Argyle Street, Argyle Square, London (proposed by A. Fowler).

Eighty-three presents were announced as having been received since the last meeting, including, amongst others—

H. S. Davis, The Variation of Latitude at New York City, Part I., declinations and proper motions of fifty-six stars, pre-

sented by the author; Göttingen, Astronomische Mittheilungen der k. Sternwarte, IV. W. Schur, Oerter der helleren Sterne der Praesepe, presented by the Observatory; B. d'Engelhardt, Observations faites dans son observatoire à Dresde, III., presented by M. d'Engelhardt; C. Mönnichmeyer, Beobachtungen von Nebelflecken, presented by the Bonn Observatory; five original negatives of the Moon, and photograph of *Saturn*, presented by the Lick Observatory; lantern slide of the *Hercules* cluster, presented by Mr. W. E. Wilson; lantern slide from photograph of a meteor, presented by Mr. C. P. Butler; two photographs of the 28-inch equatorial, presented by the Astronomer Royal; photograph from a drawing of the Moon by John Russell, R.A., presented by Mr. E. J. Stone; and photograph of the nebula M 33 *Trianguli*, presented by Dr. Roberts.

The Mont Blanc Observatory.

The President and Council of the Royal Society have communicated to the Council of this Society the following letter from M. Janssen, which is printed here (according to a resolution of Council on December 13) for the information of Fellows:—

Meudon, 25 octobre, 1895.

Monsieur le Président,

J'ai l'honneur d'offrir à la Société le premier tirage du Compte Rendu de ma dernière ascension à l'Observatoire du Mont Blanc.

Je saisis cette occasion pour assurer aux savans anglais qui voudraient bien faire des travaux à l'Observatoire que nous ferions tout ce qui dépendrait de nous pour leur faciliter ces travaux dont nous serions heureux.

(Signed) J. Janssen.

A Universal Catalogue or Subject Index.

The following letters have been received from the Royal Society and referred by the Council of this Society to the Secretaries, as Editors of the Society's publications :—

I.

The Royal Society,
Burlington House,
December 3, 1895.

Dear Sir,

The International Catalogue Committee of the Royal Society, which is engaged in considering steps for the due indexing of scientific literature, has requested the Council of the

Royal Society to arrange that in the *Philosophical Transactions* and *Proceedings* of the Royal Society each paper should be accompanied by such a statement of its contents as would serve for use in the preparation of a subject index. If this were generally done the preparation of a subject index would be greatly helped, and I am directed by the Committee to suggest the same course of action to your Society, as well as to all the other principal scientific societies.

Yours truly,

M. FOSTER, Sec. R.S.

The Secretary,
Royal Astronomical Society.

II.

The second letter is a circular letter addressed by the Secretaries of the Royal Society to its Fellows (and others), illustrating more explicitly what is required.

Royal Society,
Burlington House, London, W.

DEAR SIR,

Seeing that the title only of a paper is in most cases insufficient as a guide to its proper classification in a subject index—several topics, each demanding a separate entry, being often treated of in one paper—the President and Council of the Royal Society, with the view of facilitating the preparation of subject indices to scientific papers published by them, have resolved to ask every author communicating a paper to the Royal Society to add a condensed statement of the topics treated of, such as would facilitate the proper references to his paper in a subject index.

We subjoin a specimen statement which may help to explain what is intended.

We are,

Yours faithfully,

M. FOSTER,
RAYLEIGH, } *Secretaries.*

ORIGINAL TITLE FOR AUTHORS' INDEX.

BLACKMAN, F. F.

Experimental Researches on Vegetable Assimilation and Respiration.
No. I.—New Method for investigating the Carbonic Acid Exchanges of Plants.
No. II.—Paths of Gaseous Exchange between Aërial Leaves and the Atmosphere.

SUBJECT INDEX.

Assimilation, vegetable.
Carbonic acid absorbed and given out by leaves, estimation of.
" exhaled from leaves by stomata alone.
" solubility in oils, &c.
Gaseous exchanges in plants.
Leaves, paths of gaseous exchange.
Plants, gaseous exchanges of.
Respiration, vegetable.
Stomata, site of exhalation of carbonic acid.

In accordance with the suggestions contained in these letters, the Secretaries would ask authors of papers intended for publication by this Society to enclose with each paper a "condensed statement of the topics treated of." It will probably be some little time before a satisfactory uniform system is arrived at, and the Secretaries will welcome any suggestions which may conduce to this desirable end. For the present the particulars furnished by the authors themselves will generally be printed as they stand ; or if any additions are made by the Editors these will be clearly indicated.

E. W. MAUNDER,
H. H. TURNER, } *Secretaries.*

Note on Hansen's Lunar and Planetary Theories. By Professor Ernest W. Brown.

The integration of the equations for the mean anomaly and the radius vector in Hansen's lunar theory depend chiefly on the calculation of a certain function $\overline{\mathrm{W}}$ which has the value *

$$\overline{\mathrm{W}} = -1 - \frac{h_0}{h} + 2\frac{h}{h_0}\frac{\bar{r}}{a_0}\frac{1 + e\cos(\bar{f} + n_0 yt + \pi_0 - \chi)}{1 - e_0^2}.$$

In this expression h, e, χ refer to the instantaneous ellipse, and therefore, in disturbed motion, they are implicit functions of the time ; h_0, n_0, y, π_0 are absolute constants referring to a certain auxiliary ellipse, of constant size and shape, situated in the plane of the instantaneous orbit, the mean anomaly of this ellipse being denoted by $n_0 z$. In undisturbed motion, $n_0 z$ is of the form, $n_0 t$ + *const.* ; in disturbed motion, $n_0 z$ contains, in addition, terms depending on the action of the Sun, and it is therefore a function of the time. The symbols $\bar{r}$, $\bar{f}$ denote the radius vector and true anomaly of the point on the auxiliary ellipse where the latter is cut by the radius vector of

* *Darlegung der theoretischen Berechnung, &c., Abh. der K. Sächs. Ges. der Wiss.* vol. vi. p. 104.

the Moon ; they are therefore functions of the one variable z and thence of the time.

It is necessary to insert, in the above expression for $\overline{W}$, the disturbed values of h, e, χ ; but instead of finding their values directly, Hansen differentiates W with respect to the time and then inserts the values of dh/dt, de/dt, $d\chi/dt$, thus reducing the three integrations to one. In performing the differentiation and subsequent integration of $\overline{W}$ he has shown that we may consider $\bar{r}, \bar{f}$ as constants. The proofs of the theorems * by which this result is obtained are long and, as regards the particular function of the elements used by Hansen, unnecessary ; the theorem can, in fact, be shown to be a simple application of the integral calculus.

The above expression for $\overline{W}$ may be put into the form

$$\overline{W} = L_1 + L_2 \bar{r} + L_3 \bar{r} \cos \bar{f} + L_4 \bar{r} \sin \bar{f},$$

where L_1, L_2, L_3, L_4 contain t only through h, e, χ, $n_c yt$. In the expressions for $\bar{r}, \bar{f}$ in terms of z (or of t), suppose that t be replaced by τ and z by ζ, and let $\bar{\rho}$, $\bar{\phi}$ denote the resulting expressions of $\bar{r}, \bar{f}$. Then, considering τ, and therefore ζ, as constant, we may write

$$\begin{aligned} W &= \int \frac{dL_1}{dt} dt + \bar{r} \int \frac{dL_2}{dt} dt + \bar{r} \cos \bar{f} \int \frac{dL_3}{dt} dt + \bar{r} \sin \bar{f} \int \frac{dL_4}{dt} dt \\ &= \left[\int \left\{ \frac{dL_1}{dt} + \bar{\rho} \frac{dL_2}{dt} + \bar{\rho} \cos \bar{\phi} \frac{dL_3}{dt} + \bar{\rho} \sin \bar{\phi} \frac{dL_4}{dt} \right\} dt \right]_{\tau = t} \end{aligned}$$

If, then, we denote by W the value of $\overline{W}$ when $\bar{\rho}, \bar{\phi}$ replace $\bar{r}, \bar{f}$ in the expression first given, we have

$$\overline{W} = \left[\int \frac{dW}{dt} dt \right]_{\tau = t}.$$

That is to say, the expression for $\overline{W}$ can be differentiated, the disturbed values of the elements substituted, and the resulting expression integrated, with $\bar{r}$, $\bar{f}$ constant during the whole process. The object of the introduction of τ, $\bar{\rho}$, $\bar{\phi}$ is merely to prevent confusion between the quantities which remain variable and those which are considered constant.

The same result is available in the planetary theory,† but it is somewhat simplified by the absence of the term $n_c yt$.

Haverford College, Pa.:
1895 October 9.

* *Fundamenta nova, &c.*, pp. 22–25. *Commentatio de corporum cœlestium perturbationibus. Astr. Nach.* vol. xi. col. 322.

† *Auseinandersetzung einer zweckmässigen Methode, &c., Abh.* vol. v.

Note on the Discovery of the Graphical Method for Solving Kepler's Equation by means of a Curve of Sines. By T. J. J. See, A.M., Ph.D. (Berlin).

Through the courtesy of the Secretary, Dr. K. Zelbr, of Brünn, recently of the Imperial Observatory of Vienna, has called my attention to the fact that the method for solving Kepler's Equation by means of a curve of sines, given in the *Monthly Notices* for June, and usually attributed to Dubois, of Brest, was in reality discovered by an Englishman, J. J. Waterston, Esq. A short abstract of his paper appears in the *Monthly Notices* for 1849–50, p. 169, and is entitled, "On a Graphical Mode of Computing the Eccentric Anomaly." Dr. Zelbr writes that this error in regard to the original discoverer occurs in several standard astronomical works, notably in Wolf's *Handbuch der Astronomie*, and Klinkerfues' *Theoretische Astronomie*, from which it seems fairly certain that Waterston's discovery of this important method has been generally overlooked.

Klinkerfues' discussion first directed my attention to the method, and as Dubois in *Astron. Nachr.* 1404 makes no mention of any previous discovery, I assumed with Klinkerfues that Dubois had been the first to detect the possibility of such a solution. It is clear, however, from the concise abstract printed in the *Monthly Notices* for 1849–50, that Waterston had preceded Dubois by about fourteen years; and while Dubois' discovery seems to have been independent of Waterston's, the latter has the undoubted right of priority.

I cannot but remark how singular it is that a method of such great practical importance should rest in comparative oblivion during half a century at a time when astronomers were constantly working on the motions of periodic comets and double stars; but it is probable that neither Waterston nor Dubois recognised the great generality and high value of the method in practical work. Since writing the paper which I communicated to the Society at the June meeting I have had occasion to make great use of the method in revising the orbits of double stars, and have found it, not only the easiest and most rapid process yet invented, but one altogether so satisfactory that we may predict its universal adoption by astronomers. The simplicity and generality of the method and the rapidity and accuracy with which solutions can be obtained invite the inference that in the nature of the case the method is probably ultimate, and is not likely to be improved upon in any future age.

The true history of an important discovery is always interesting, and while Waterston's work does not diminish the credit

due to Dubois for an independent result, it will yet be gratifying to the present Fellows of the Society to know that the original discovery was made by a countryman and a contemporary of Sir John Herschel.

The University of Chicago:
1895 *October* 22.

Micrometrical Determinations of the Diameters of the Minor Planets Ceres (1), *Pallas* (2), *Juno* (3), *and Vesta* (4), *made with the Filar Micrometer of the* 36-*inch Equatorial of the Lick Observatory, and on the Albedos of those Planets.* By E. E. Barnard.

In *Monthly Notices of the Royal Astronomical Society*, vol. liv. No. 9, I have given a series of micrometer measures of the diameters of the asteroids *Ceres* (1), *Pallas* (2), and *Vesta* (4) made with the great telescope.

These measures have been continued this year, except in the case of *Pallas*, whose greatly increased distance discouraged any measures of it.

I have also secured measures of *Juno* on four nights. The disc of this object, however, was extremely small, and so nearly the size of the spurious disc of a star of the same magnitude that it must for the present, perhaps, be taken as showing only the possible maximum diameter.

I am confident, however, that the real disc was seen, as it seemed to sensibly enlarge with the higher powers.

On each night, while under observation, this asteroid was micrometrically referred to some star near it for motion, so that no mistake was possible in its identification.

Ceres has been running very far south—some 28° of south declination. This has made it rather difficult; but no measures were attempted unless the disc was clearly seen.

The measures were made with 1,000 diameters, except in one or two instances, when 1,500 was used. On one or two occasions 2,600 was also employed. But 1,000 was found more uniformly satisfactory.

For completeness of this paper I have added to these measures my observations of 1894 (including those of *Pallas*).

Micrometrical Measures of the Diameters.

Ceres (1).

		Obsd.	At Δ 2·7673.	δ
		″	″	″
1894. Mar.	12	0·75	0·44	−0·05
	25	0·72	0·43	−0·04
Apr.	1	0·73	0·44	−0·04
	9	0·58	0·36	+0·03
	16	0·60	0·39	0·00
	23	0·59	0·40	−0·01
	30	0·58	0·40	−0·01
May	7	0·47	0·34	+0·05
1895. May	12	0·53	0·40	−0·01
	13	0·56	0·42	−0·03
June	2	0·60	0·41	−0·02
	3	0·56	0·39	0·00
	17	0·67	0·45	−0·06
	23	0·47	0·32	+0·07
	24	0·64	0·43	−0·04
	30	0·48	0·32	+0·07
July	1	0·63	0·43	−0·04
	7	0·62	0·43	−0·04
	8	0·48	0·33	+0·06
	14	0·55	0·38	+0·01
	15	0·57	0·40	−0·01
Aug.	4	0·44	0·33	+0·06
	5	0·43	0·32	+0·07
			0·389	

or at $\Delta 1 = 1''{\cdot}076$.

In the measures of *Ceres* in 1894 I have omitted the observation of March 11, as all the other measures show it was too large.

Pallas (2).

		Obsd.	At Δ 2·7673.	δ
		″	′	″
1894 Feb.	25	0·75	0·34	−0·10
	26	0·59	0·26	−0·02
Mar.	11	0·44	0·21	+0·03
	12	0·46	0·21	+0·03
	25	0·40	0·20	+0·04
			0·244	

or at $\Delta 1 = 0''{\cdot}675$.

Juno (3).

		Obsd.	At Δ 2·7673.	δ
1895.		″	″	″
July	21	0·16	0·11	−0·02
	22	0·14	0·10	−0·01
Aug.	4	0·12	0·09	0·00
	5	0·11	0·08	+0·01
			0·095	

or at Δ1 = 0″·263.

Vesta (4).

		Obsd.	At Δ 2·7673.	δ
1894.		″	″	″
Mar.	11	0·38	0·23	−0·04
	12	0·46	0·22	−0·03
	25	0·33	0·16	+0·03
Apr.	1	0·39	0·20	−0·01
	9	0·29	0·15	+0·04
1895.				
July	7	0·35	0·19	0·00
	8	0·44	0·24	−0·05
	14	0·41	0·21	−0·02
	15	0·42	0·22	−0·03
	21	0·38	0·19	0·00
	22	0·38	0·19	0·00
Aug.	4	0·40	0·19	0·00
	5	0·42	0·20	−0·01
	11	0·43	0·20	−0·01
	12	0·35	0·17	+0·02
	18	0·43	0·20	−0·01
	19	0·40	0·19	0·00
	25	0·40	0·19	0·00
			0·195	

or at Δ1 = 0″·540.

δ in each case is the deviation from the mean.

No correction has been applied for irradiation, since it is not only an unknown quantity, but must also be inappreciable in these measures. No correction has been applied for phase, because the measures were made at and near opposition, and the correction would be insensible.

Collecting the results, we have for the diameters of

	At Δ 2·7673.	At Δ 1.
	"	"
Ceres	0·389	1·076
Pallas	0·244	0·675
Juno	[0·095]	[0·263]
Vesta	0·195	0·540

Reduced to English miles, these become, for

Diameter of Ceres (1) = 485 miles
„ Pallas (2) = 304 „
„ Juno (3) = [118] „
„ Vesta (4) = 243 „

In comparing the measures for the two years, it will be seen that in the main they are perfectly accordant. Those of the present year were not reduced until the close of the work. The observations are therefore free of bias.

These results, I believe, are very accurate, and I think we have now for the first time satisfactory information of the dimensions of at least three of the four brightest asteroids. I feel sure that the diameters of *Ceres*, *Pallas*, and *Vesta* are now as well known as are those of the four bright moons of *Jupiter*.

I hope to take up the measurement of these bodies with more powerful optical means in the near future, and, if possible, extend the list to other members of the asteroidal group. In the winter of 1896 *Juno* will be very favourably placed for measurement, and I shall hope then to get good measures of it.

Previous Efforts to determine the Diameter of these Asteroids.—A friend has called my attention to a recent paper by Mr. H. Sadler, containing a collection of the various previous efforts to determine the diameters of these four asteroids. Mr. Sadler's paper can be found in the *English Mechanic* for August 2, 1895, p. 533.

Because of the importance of the subject, I will copy here the results he gives for previous observations.

Ceres (1).

Schröter (diameter) ...	1,570 miles	Bruno ...	227* miles
Wm. Herschel ...	162 „	Galle ...	396 „
Argelander	225* „	Knott ...	630 „

Pallas (2).

Schröter	2,025 miles		
Wm. Herschel	122 „		
„	also 83 and 70 miles, "almost incredibly small."		
Lamont ...	667 miles	Bruno ...	171* miles
Argelander ...	158* „	Pickering ...	167* „

Juno (3).

Schröter ...	1,380 miles	Stone ...	124* miles
Argelander ...	105* „	Pickering ...	94* „
Bruno ...	115* „		

Vesta (4).

Schröter ...	333 miles	Secchi ...	450 ± miles
Mädler ...	290 „	Tacchini ...	880 „
Argelander ...	270* „	Millosevich	630 „
Bruno ...	230* „	Pickering ...	319* „
Stone ...	214* „		

The diameters marked with an asterisk (*) were derived by photometric means.

The general agreement of these photometric values is doubtless due to essentially the same data being employed by each of the astronomers.

Mr. Sadler had evidently not seen Dr. G. Müller's elaborate photometric observations of three of these four asteroids—viz. *Ceres*, *Pallas*, and *Vesta*. Dr. Müller's work comprises No. 30 of the Publications of the Astrophysical Observatory of Potsdam, 1893. He deduces the dimensions of these three bodies on two suppositions. First, that their albedo is equal to that of *Mercury*; second, that it is equal to that of *Mars*.

His results are :—

	I. Radius.	II. Radius.
Ceres	475 kilom.	379 kilom.
Pallas	354 „	282 „
Vesta	473 „	377 „

These give the following *diameters* in English miles :—

	I.	II.	Means.
Ceres	594 miles	474 miles	534 miles
Pallas	442 „	352 „	397 „
Vesta	591 „	471 „	531 „

The uncertainty of the photometric method in determining the dimensions of these bodies is well shown by the large differences in the results derived by even this moderate range of assumed albedo.

In reality there is a very wide range of albedo among the asteroids themselves—at least as great as that found among the planets.

This is not surprising, for even in so closely related bodies as the four bright moons of *Jupiter*, there is a very great range of albedo.

From my measures it is now possible to determine the albedos of these four asteroids with considerable precision.

Professor Arthur Searle, of the Harvard College Observatory, has kindly supplied me with the photometric magnitudes of *Ceres*, *Pallas*, *Juno*, and *Vesta*, as determined at Harvard College Observatory, and by Mr. H. M. Parkhurst at Brooklyn, N.Y.

These values, reduced to mean opposition and to distance unity, are :—

Ceres.

	At M. Opp. m.	At Δr. m.
H.C.O. Merid. Photom. Observers, Pickering and Wendell (15*n*)	7·72	4·27
Brooklyn, N.Y. H. M. Parkhurst	...	3·74
H.C.O. Wedge Photom. Observer, Wendell (16*n*)	7·24	3·84

Pallas.

H.C.O. Merid. Photom. Pickering and Wendell (17*n*)	8·48	5·02
Brooklyn, N.Y. H. M. Parkhurst	...	4·50

Juno.

H.C.O. Merid. Photom. Pickering and Wendell (15*n*)	9·50	6·26
Brooklyn, N.Y. H. M. Parkhurst	...	5·77

Vesta.

H.C.O. Merid. Photom. Pickering, Searle, and Wendell (22*n*)	6·47	3·93
Brooklyn, N.Y. H. M. Parkhurst	...	3·49
H.C.O. Wedge Photom. O. C. Wendell (23*n*) ...	6·79	4·25

Müller's photometric values from the Potsdam observations are :—

	At Δr. m.		At Δr. m.
Ceres	3·46	Vesta	3·47
Pallas	4·10		

The means of these different determinations are :—

	At Δ_1.		At Δ_1.
	m.		m.
Ceres	3·83	Juno	5·91
Pallas	4·55	Vesta	3·79

It will be seen that these various determinations by different observers differ in some cases by nearly an entire magnitude.

Albedos.—Müller gives the magnitude of Mars = − 1·297. From the above values of the magnitudes I have derived, from my diameters, the following albedos of these four asteroids :—

Albedos (*Mars* = 1·00).

Ceres	0·67	Juno	1·67
Pallas	0·88	Vesta	2·77

Müller has determined the albedos of the various planets, and it is interesting to compare these with the above.

Albedos and Magnitudes of the Planets (*Müller*).

	Albedo.	Mag. at Δ_1.
Mercury	0·64	−0·003
Venus	3·44	−4·004
Mars	1·00	−1·297
Jupiter	2·79	−8·932
Saturn	3·28	−8·685
Uranus	2·73	−6·858
Neptune	2·36	−7·053

By comparison, it will be seen that the surface of *Ceres* reflects light with about the same intensity as that of *Mercury*, *Pallas* somewhat less than *Mars*, *Juno* between that of *Mars* and *Jupiter*, while *Vesta* is about equal to that of *Jupiter*.

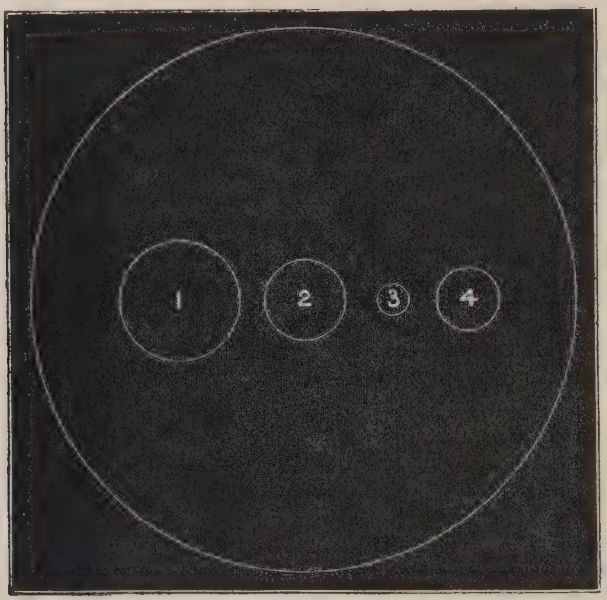
The mean albedo of the four is 1·45. This value will be a far safer standard to use in the determinations of the dimensions of the other asteroids by photometric methods than that previously adopted.

Up to the making of these measures with the 36-inch, *Vesta* was considered, from its generally greater brightness, to be the largest of the asteroids. It is now understood, from its high albedo, why it was so bright. Its surface reflects light with four times the intensity of that of *Ceres*.

It will also be readily seen that *Ceres* is really by far the largest of the asteroids.

In conclusion, I think it is scarcely necessary to add that all previous attempts at direct measures of the diameters of these small bodies were made with instruments inadequate to deal satisfactorily with such minute quantities as the asteroidal

diameters. They are far more difficult to deal with than the four bright moons of *Jupiter*.



Relative sizes of the four bright asteroids and the Moon (the inclosing circle is the Moon).

To make the relative sizes of these four asteroids apparent at once to the eye, I give a diagram made from my measures.

Professor Tucker, of the Lick Observatory, kindly and specially observed the magnitudes of these four asteroids for me with the meridian circle of the Lick Observatory. It was my intention to incorporate these visual magnitudes with the photometric values in deducing the albedos of *Ceres*, *Pallas*, *Juno*, and *Vesta*; but I finally decided to use the photometric results alone, as the albedos of the planets had been so determined by Dr. Müller. Professor Tucker's great experience in estimating magnitudes in his valuable work in observing the Cordoba D.M. will make these estimations valuable.

I herewith append his results.

Estimations of the Magnitudes of Ceres, Pallas, Juno, and Vesta.
By R. H. Tucker, Jun., 1895.

1895 July 26	Ceres	8 mag.	1895 July 31	Pallas	$8\frac{1}{4}$ mag.
26	Juno	$8\frac{1}{4}$ mag.	31	Vesta	$6\frac{3}{4}$ mag.

These are the observed magnitudes, and will be on the same scale as those of the Cordoba D.M.

Mount Hamilton, California:
1895 *August* 29.

On the Extended Nebulosity about 15 *Monocerotis.*
By E. E. Barnard.

I am somewhat surprised at Dr. Roberts' statements in *Monthly Notices*, vol. lv. No. 7, for May 1895, where he condemns the idea of the diffused nebulosity shown about 15 *Monocerotis* on my photograph of 1894 February 1.

I must also object to the unjust comparison that he has made. He has shown upon the screen a lantern slide made from my glass positive of this region, which is in the possession of the R.A.S. This he has enlarged some four or five times to compare with his *unenlarged* photograph. He finds under these conditions that my picture is coarse, and that the nebulosity to which I called attention is not real, but is due to diffused light from many small stars.

I would say that these pictures, made with a short focus lens, are not intended to be enlarged, or, if so, but slightly. If the subjects are wanted on a larger scale the best plan is to use a longer focus and bigger telescope for that purpose—such, for instance, as Dr. Roberts' reflector.

They are intended to be looked at and studied as *pictures* of the regions they show, and are not to be examined microscopically. It is unjust to use an enlargement such as Dr. Roberts used, because it necessarily puts these pictures at a disadvantage. My picture was simply spoiled by this, while Dr. Roberts retained its original qualities, not being enlarged.

An enlargement should not be made from a copy, but from the original, because a copy like this was made with special reference to showing the nebulosity; the stars therefore suffer, especially if an enlargement is made.

A short focus lens like this is not intended to show small details because of its small scale. The study of small details belongs specially to large telescopes. The short focus lens, however, is exceptionally fine for just such large diffused nebulosities as that surrounding 15 *Monocerotis*.

Dr. Roberts seems to forget, in speaking of my paper in *Astronomy and Astro-Physics*, vol. xiii. pp. 178–182, that it was I who called his attention to the fact that 15 *Monocerotis* was really nebulous, and that the closer nebulosities about this star were the special province of larger telescopes than mine.

I shall quote from the article in *Astronomy and Astro-Physics*:—

"Another photograph of the region about 15 *Monocerotis* on February 1, 1894, with three hours' exposure, shows the great nebula that envelopes 15 *Monocerotis* very much better than the previous picture. Its full extent—in diameter—can be taken roughly at 3°. It clusters densely about the groups of stars and then spreads out in a weak, diffuse light with rifts in it and irregularly terminated along the edges of a vast vacancy in the Milky Way. The condensation, which is very strong, is not at 15 *Monocerotis*, but 12′ south preceding that star, where it becomes a compact mass, with numerous wisps and holes in it. The whole group of three or four bright stars are involved in this denser wispy light, but 15 *Monocerotis* itself does not seem to be specially connected with the nebulosity further than to be apparently in it—that is, there are no indications of condensation about this the brightest star of the group. *This remarkable nebula—the denser part of it—is worthy of study with a more powerful photographic telescope. The condensed part of the nebula is only a few minutes in diameter, but it would readily photograph in a large instrument.* The place of 15 *Monocerotis* for 1860·0 is

$$\alpha = 6^h\ 33^m\ 16^s + 10^\circ\ 1'{\cdot}3.$$

It is thus described in the catalogue (N.G.C.) '15 *Monoc.* Cl.*, ? neb.'"

It will be seen by the italicised portion of this description that I was fully aware of the inability of the Willard lens to deal with the closer details of this nebula, and I suppose this really called Dr. Roberts' attention to the object.

The glass positive I sent to the R.A.S. does not show the details of this nebula close to 15 *Monocerotis*, though much detail is shown on the original negative, because, as I have said, my aim was to show the diffused nebulosity, which required a different treatment.

I forward to the Society three paper prints from an enlargement from the original negative. These pictures are printed to different depths to show the diffused nebulosity.

Dr. Roberts states that "there are vast areas on the camera plate photographed, which, to most of us, would be accepted as evidence of nebulosity with dark tortuous rifts in it, but it is not nebulosity at all. It is, in fact, the effect of the diffused light of numerous and close stars being concentrated upon the photo-film by a small instrument, and the dark rifts are only areas with fewer stars in them, by causing the appearance that the crowded star areas are involved in true nebulosity." It will be noticed that this statement cannot strictly hold in the face of the facts shown by these prints.

By examining these pictures I send, it will be seen that Dr. Roberts' reasoning is decidedly wrong.

This diffused light is in nowise confined to the star areas. It will be also readily seen that it spreads over a large region where

there are essentially no stars at all—even where Dr. Roberts' reflector can show no stars.

That this is real diffused nebulosity there is no reason whatever to doubt. The photograph shows that it begins gradually to diffuse from 15 *Monocerotis* and spreads out over a large region covering star areas and vacancies for some degrees. I think an unprejudiced inspection of these prints will prove these statements.

As a further proof that this cannot be nebulosity which his 20-inch fails to show, Dr. Roberts says his photograph shows faint stars not on my positive, though the exposure was the same.

This proof is a rather surprising one. So far as the stars are concerned, Dr. Roberts gets the full effect of the light area of a 20 inch over that of a 6-inch. It is not at all unreasonable, therefore, that he should get fainter stars than I do in the same time, for the relative light areas are as 36 to 400, the quantity of light in his case being some eleven times greater.

But when it comes to nebulous areas quite a different condition prevails, and this I do not think will follow any special law of aperture and focus.

I should expect by all means to photograph large diffused nebulous masses quicker and better with the Willard lens than with a 20-inch reflector, though the reflector ought certainly to show fainter stars.

As an illustration of this matter of photographing large diffused areas of feeble light I would refer to some photographs made with a very small lens of $1\frac{1}{2}$ inch diameter. Compared with the Willard lens the light ratio of this small lens is about $\frac{1}{3\cdot5}$ to $\frac{1}{5}$. Instead of the smaller lens being some two times as quick on large faint areas of light, it is really upwards of fifteen or twenty times as quick, if we are to take the testimony of actual work made for the past year.

But I cannot see that there is any special reason to contest for the existence of this nebulosity, for we find similar areas of nebulosity elsewhere in the Milky Way that have passed unquestioned.

In conclusion let me add that both the Willard lens and Dr. Roberts' reflector have each their special field, which in nowise conflict, but in which they mutually supplement each other for the benefit and advancement of truth and knowledge.

Mount Hamilton, California:
1895 *September* 6.

Invisibility of Hind's Variable Nebula (N.G.C. 1555).

By E. E. Barnard, D.Sc., A.M.

In *Monthly Notices*, No. 8, vol. lv. pp. 442–452, I have given an historical account of the variable nebulæ of Hind and Struve (N.G.C. 1555 and 1554). I have also given the observations and measures of Mr. Burnham and myself of these two objects.

I have naturally become very much interested in these nebulæ, and have taken the first favourable opportunity to examine the region again with the 36-inch.

To my surprise no trace of Hind's nebula now exists—it seems to have entirely vanished! I have examined the place of this object several mornings lately under the very best conditions, but the variable nebula could not be seen.

τ Tauri was identified with certainty on each occasion. To be absolutely sure of the identification I again measured its position with reference to the W.B. star $4^h{\cdot}274$ south preceding it.

1895·73 $\Delta\delta$ (τ Tauri − WB $4^h{\cdot}274$) = $+243''{\cdot}66$

1895·73 $\Delta\alpha$ ( ) = $+0^m\ 16^s \pm$.

I also measured the $\Delta\delta$ between the small 14^m star, which stands in the position assigned the Struve nebula and the W.B. star.

1895·73 $\Delta\delta$ ($14^m \star$ − WB $4^h{\cdot}274$) = $+189''{\cdot}27$.

These measures are in perfect accord with those in the article above referred to, and the identification is complete. The place was also in perfect accord with the diagrams in *Monthly Notices*, No. 8, vol. lv. pp. 444–450.

Every means was tried to see Hind's nebula: *τ Tauri* was occulted, the place was examined with averted vision, but no strain of eyesight could detect any trace of the nebula. If it had been as bright as at the observations in February last it would have been easily visible, as the conditions for seeing it were better. This proves my conjecture that this nebula still fluctuates in its light. It is certainly now invisible in the 36-inch. The place of this object should therefore receive careful attention with powerful telescopes to see when the nebula reappears.

With the utmost difficulty I could see an excessively faint star about $10''\pm$ south of the Struve star. It could not be brighter than the 17 mag., as it was at the very limit of the 36-inch. I could not be certain that this faint object was really stellar; sometimes it looked nebulous. It is impossible, however,

to decide as to the nebulous condition of an object of this kind when at the limit of visibility.

τ Tauri was about as bright as the star A of my former paper, and seemed to be involved in a small hazy nebulosity ; but the definite nebula in which it shone in 1890 did not exist.

These observations have been made under the best conditions, with the objects on the meridian, upon the following dates :—

1895 September 15, 22, and 23.

Mount Hamilton, California :
1895 *September* 24.

Note on some Remarks of Mons. O. Callandreau in the "Bulletin Astronomique" for November 1895. By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

In the *Bulletin Astronomique* for November 1895, p. 458, there are some remarks by Mons. O. Callandreau, which bear upon my papers on time measurement. But as my papers on this subject have nearly all been printed in the *Monthly Notices*, it is, perhaps, desirable that the few words which I consider necessary in the way of reply should also appear in these publications.

M. Callandreau states, with perfect accuracy, that I base my measures of t, fundamentally, upon the Sun's mean longitude. But he expresses himself as follows :—

"On voit dans l'article dont il s'agit que M. Stone, rompant avec l'habitude des astronomes de mesurer le temps par l'angle horaire du Soleil, procède comme si la longitude moyenne du Soleil devait servir à la mesure du temps.

"Les deux manières sont également admissibles à un point de vue abstrait."

I have given this statement in M. Callandreau's own words on account of its importance.

I hardly think, however, that this statement, *as it will generally be understood*, can be accepted as correct.

If astronomers did, as a matter of fact, consistently and exclusively use a system of time-measures, t', which had no connection whatever with the system of time-measures, t, based on the Sun's mean motion in longitude, which I employ, then it might be possible to admit that my views were mathematically sound, but of no practical importance in the existing state of astronomy. But I have proved, or profess to have proved—whether rightly or wrongly may now be taken as the real point at issue—that astronomers *use in their mathematical investigations* measures of time, t, based directly on the Sun's mean motion in longitude ; and, if there is any change of usage, which I assert to be the case, it is they who break away from the fundamental

system of time-measures, t, in terms of which their mathematical formulæ are expressed ; when, on account of the practical difficulties in finding the variable, t, directly from the observations of the Sun, they attempt to determine it from the motion of the meridians in right ascension, or from the relative motions of the meridians and of the Sun in right ascension. Such methods of finding the variable, t, are things much to be desired. And they would be practically successful, for all the values of n' which could be adopted in our theoretical investigations, if the rotation of the Earth on its axis was, as is supposed, constant and the exact *ratio* of the mean motion of a meridian to that of the Sun in R.A. was known. But such is not the case. And the required variable, t, cannot, therefore, be *accurately found* in either of these ways. I believe this is now generally acknowledged.

Approximate values of t can be and are thus found by the use of approximate values of the *ratio* already referred to. But in estimating the errors made by the process adopted, it is necessary to take the error of the adopted value of the constant *ratio* into consideration.

This is what I have done in all my formulæ ; and this is what astronomers have hitherto neglected to do. But the terms which I have added to the expression of the R.A. of a meridian as a function of t are certainly required if the measure of the time, t, is based on the Sun's mean longitude. If such had not been the case my formula would have been proved to be erroneous long before this.

To disprove the practical bearing of my views, it is necessary, therefore, that someone should show that astronomers do not establish a connection between the unit in terms of which t measures the time in their mathematical expressions, and n', *the Sun's mean motion in longitude in the unit of time*, when they eliminate from the differential equations of motion the accelerating effects of the mass of the Sun, m', or of the sum of the masses of the Sun and of the Earth, $m'+\mathrm{E}$, or the sums of the masses of the Sun, Earth, and Moon, $m'+\mathrm{E}+m$, by conditional equations such as

$$m' = a'^3 n'^2$$

or

$$m' + \mathrm{E} = \mathrm{A}'^3 n'^2$$

or

$$m' + \mathrm{E} + m = \mathrm{A}''^3 n'^2 ;$$

assume the ratios of the accelerating effects of all the masses to that of the Sun to be constants independent of the units of length and of time, a condition which requires the same units of length and of time to be adopted in all the mathematical expressions ; and find the connection between the linear constants a', or A', or A'', and the Sun's distance r', and those between the corresponding results of observation and the other linear and

angular quantities which appear in their mathematical work subject to one of the conditions mentioned.

I feel some confidence from the serious consideration which I have given to the question, that not only cannot this be shown, but that I have clearly shown the converse to be true. These proofs can be made absolutely rigorous, but they necessarily become somewhat long and formal if every elementary step has to be given.

Note on Newcomb's Tables of the Sun. By A. M. W. Downing, M.A., D.Sc.

Remarking on the large annual term exhibited in the comparison of Le Verrier's and Newcomb's Solar Tables, printed in the supplementary number of the *Monthly Notices* (vol. lv.), Professor Newcomb has pointed out to me that the definitive correction to Le Verrier's value of the eccentricity of the Earth's orbit for 1900, as found in his *Elements and Astronomical Constants* and adopted in the Solar Tables, is $+0''\cdot20$. The effective correction to Le Verrier's longitude of perigee for the same epoch is $+6''\cdot3$.

Calling these quantities δe and $\delta\pi$ respectively, we have the corresponding correction to the longitude :

$$\delta l = \frac{dl}{de} \cdot \delta e + \frac{dl}{ed\pi} \cdot e\delta\pi.$$

But

$$\frac{dl}{de} = \quad 2 \sin g$$

$$\frac{dl}{ed\pi} = -2 \cos g$$

where g is the mean anomaly.

Therefore,

$$\delta l = +0''\cdot40 \sin g - 0''\cdot21 \cos g.$$

Applying this correction to the comparison referred to above, we have (taking the mean of each three consecutive corrections for convenience) :—

Date 1900.	Residual Correction.	Date 1900.	Residual Correction
	"		"
Jan. 9	−0·27	July 20	−0·53
Feb. 2	−0·25	Aug. 13	−0·62
26	−0·26	Sept. 6	−0·57
Mar. 22	−0·33	30	−0·60
Apr. 15	−0·42	Oct. 24	−0·66
May 9	−0·42	Nov. 17	−0·73
June 2	−0·40	Dec. 11	−0·65
26	−0·46	27	−0·73

By the application of the corrections for eccentricity and longitude of perigee, the outstanding corrections become, therefore, corrections of a sensibly progressive character throughout the year under consideration. These progressive corrections arise doubtless from differences in the tables of perturbations given by Newcomb and Le Verrier respectively.

Photograph of the Spiral Nebula M. 33 Trianguli.

By Isaac Roberts, D.Sc., F.R.S.

The photograph of the spiral nebula M. 33 *Trianguli*, R.A. $1^h\ 28^m$, Decl. 30° 7′ north, was taken with the 20-inch reflector on 1895 November 14, with exposure of the plate during 2 hours and 15 minutes, and the copy now presented is enlarged to the scale of 1 millimetre to 24 seconds of arc.

The nebula is N.G.C. No. 598, G.C. No. 352, h 131, Rosse, *Obs. of Neb. and Cl. of Stars*, p. 20 ; *Phil. Trans.* 1850, pl. 36, fig. 5, and 1861 pl. 36, fig. 10.

Sir J. Herschel (G.C. 352) describes the nebula as a remarkable object, extremely bright, extremely large, round, very rich, very gradually brighter in the middle with a nucleus, and resolvable.

Lord Rosse (references given above) has recorded 32 observations made between the years 1849 and 1862, and gives a marginal sketch. These make us acquainted with the difficulties encountered by the observers in their efforts to make intelligible, by descriptive matter and by drawings, an object having a structure so complex that no eye and hand, however well trained, could possibly delineate it.

The photograph shows the nebula to be a spiral with remarkable features. The nebula measures about 62 minutes of arc from *north following* to *south preceding*, and 35 minutes from *south following* to *north preceding*.

It will be observed that there are two large, very prominent, spiral arms, with their respective external curvatures facing north and south, and that the curves are approximately symmetrical from their extremities to their point of junction at the centre of revolution, where there is a nebulous star of about tenth magnitude with dense nebulosity surrounding it, and elongated in *north* and *south* directions. Involved in this nebulosity are three bright stars and several faint nebulous stars ; the two arms also are crowded with well-defined stars and faint nebulous stars with nebulosity between them ; and it is to the combined effect of these that the defined forms of the arms are due. Besides these two arms there are subsidiary arms, less well defined, and likewise trending towards the centre of revolution, and are constituted of interrupted streams of faint stars and nebulosity intermingled

together ; many of the stars are nebulous and many are well defined but small. The interspaces between the convolutions are more or less filled with faint nebulosity, having curves, rifts, fields, and lanes, without apparent nebulosity in them. They are like the interspaces in clouds of smoke, and cannot be classified.

There are outliers of nebulosity with many small well-defined and nebulous stars involved in them, and there are also isolated nebulous stars on the extreme boundaries of the nebula ; but the evidence is strong that they are all related to the nebula.

It is by the study of the photographs, and not by descriptive matter, that we can form a true conception of the character of this nebula ; from which we shall be justified, even now, in drawing some inferences as to its formation and further developments. To this end I may be permitted to suggest the following.

We know, with a reasonable amount of certainty, that both nebulous and meteoric matters exist in space ; and we also have some evidence that bodies in space have come into collision.

From these premises we may infer that this nebula is the result of a collision of some kind ; and we can imagine collisions of at least three kinds possible ; namely, (1) between two stars, (2) between two nebulæ, (3) between two swarms of meteorites.

In the case of this nebula, which (if any) of the three possibilities mentioned seems to us the one most probable to have happened ? Much might be said in favour of each of these suggestions, but I shall not at present enter into details, though I think we could readily imagine that the collision of two swarms of meteorites, moving in opposite directions, one from the *south following* and the other from the *north preceding*, would account for the spiral appearance, the rotary motion, and the smashed and scattered state in which the nebula is shown to us upon the photographs.

Two photographs of the nebula have been taken, one on 1891 November 11, and the present photograph on November 14 (last month). I have examined these with some care, and found all the stars and the nebulosity, on both plates, to be sensibly coincident, after the lapse of an interval of four years ; and unless the object were comparatively near to us, this result is what we should expect to find.

The spiral nebulæ M. 101 *Ursæ Majoris* and M. 74 *Piscium*, photographs of which we will now project on the screen, are very similar in character to M. 33 *Trianguli* ; but they are more symmetrical in outline, and appear to have arrived at a more advanced stage in their development. Another inference which may fairly be drawn is, that upon photographs of spiral nebulæ, and of globular clusters, we shall first find conclusive evidence of structural changes taking place, together with the import of such changes ; though a period of four years is too short to enable us to prove that any obvious change has taken place in the spiral nebula M. 33 *Trianguli*.

On the Proper Motion of Lacaille, 4336, *Mag.* 5·5.

By R. T. A. Innes.

This star (R.A. $10^h\ 26^m\ 42^s$, Dec. $-53°\ 6'$, 1880) with a 8·2 mag. companion (Cordoba Zones 10^h, 1929) makes the pair *h* 4329 of which I have found the following measures :

1837·1	17°·1	17″·5	*h*	2 nights
1846·3	29·6	17·5	Jacob	
1873·2	63·7	21·9	Russell	1 night
1881·5	71·7	23·4	Hargrave	,,

This star is sometimes called *Y Velorum* : it is a white star, the *comes* being red, according to *h* and Russell.

The change of position is well accounted for by applying to Lac. 4336 a proper motion of 0″·44 towards 297°·5, or R.A. $-0^s·043$ Dec. $+0''·203$. This proper motion is not too inconsistent with the positions I have at hand, viz. the B.A.C., the A.G.C., and Stone's Cape Catalogue.

It has occurred to me that, if Mr. Stone were asked, he would kindly supplement my remarks with a comparison of the meridian observations, which might be somewhat reconciled with each other now that we have an independent determination of the proper motion.

Sydney: 1895 *November* 1.

Mr. Innes's conclusion that the alterations in position angle and distance of these two stars are principally due to the proper motions of the star, Lacaille 4336, appears to me quite correct. I find on reference to my manuscript of proper motions that the principal star has proper motions of about $-0^s·051$ in R.A. and $-0''·16$ in N.P.D. The first depends entirely upon a comparison between Taylor and Stone, and probably requires a correction of about $+0^s·005$ on account of systematic errors of Taylor's R.A. The proper motion in N.P.D. depends on comparisons between Stone and four other catalogues.—E. J. Stone.

Setting Apparatus for a Transit Circle. By W. E. Cooke, M.A.

(*Communicated by the Secretaries.*)

I beg to offer the following suggestions for an apparatus to facilitate setting a transit circle in Z D. I cannot attempt to enter into details, for so much depends upon the shape of the instrument and the class of work for which settings are required. But the general idea will be readily grasped by the aid of figures 1 and 2, where 1 represents the apparatus viewed from north or south, 2 from east or west. C is a light flanged or grooved circle attached to the axis, parallel to and about the same size as the graduated circle. Attached to the rim is a non-extensible cord, the end hanging vertically and carrying a pointer P. The diagram shows P as a framework, across the middle of which a horizontal thread is stretched, capable of a small vertical adjustment by means of a rackwork.

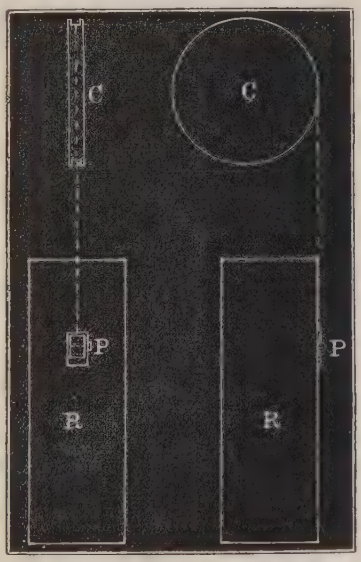


Fig. 1. Fig. 2.

As the telescope is revolved, P will move up or down, and its vertical height above any arbitrary fixed point will give an indication of the declination of the star towards which the telescope is directed.

R is a vertical cylinder which rotates by clockwork once in twenty-four sidereal hours, and can be readily adjusted on its

revolving spindle if necessary. Upon its surface a sheet of paper is stretched, on which lines are drawn to represent R.A. and Dec. The R.A. lines are obtained by dividing the circumference of the cylinder into 24 hours &c., and the distance separating the successive lines of declination is obtained from the vertical moment of P. After drawing these lines, all clock stars and all those stars included in the current working list can be plotted and the cylinder mounted. It is adjusted in the first place so that the sidereal time at the instant of mounting corresponds to the same moment of R.A. on the cylinder opposite the centre of P. The apparatus is now ready for use, the only attention required being the occasional winding up of the clockwork.

The rotation of R will bring each star in succession opposite the middle of P (or rather opposite a vertical line through this point) at the moment the real object crosses the meridian, and by moving the telescope until the cross hair of P cuts the picture of the star, we shall bring the object itself into the field of view.

The observer therefore will not require either a sidereal clock or a star list for setting purposes. Standing in front of the telescope he sees by a glance at the cylinder what stars are approaching the meridian, and he sets for any particular one by simply revolving the instrument until the cross hair of P bisects the picture of the selected object.

Adelaide Observatory:
1895 *September* 10.

The Radiant Point of the October Meteors (Orionids).

By W. F. Denning.

So many meteor-showers are now known or suspected, and the great proportion of them are of such feeble and uncertain character, that it seems scarcely desirable to multiply them by further observation. Instead of searching for new and feeble systems, the meteor observer would perhaps be better engaged in directing attention to the rich periodical streams, and investigating their peculiarities with more closeness than has been done hitherto.

It is certain that the features of moving and stationary radiants cannot be well examined in regard to the very feeble showers, but that we must select prominent displays, and such as are pretty durable, like the *Perseids* and *Orionids*. Streams of this character are sufficiently rich and prolonged to be traced very satisfactorily on many successive nights, whereas the minor systems are so tenuous, and apparently so intermittent, that the observer finds it extremely difficult to gather sufficient

materials to test their visible behaviour. The *Perseids* have already been found to form a radiant subject to a very obvious and rapid motion to the eastwards amongst the stars (*Monthly Notices*, xxxviii. p. 308, and xlv. p. 97–8). But the *Orionids* appear to be typical of a shower having a fixed radiant during the whole time of its presentation (*Monthly Notices*, l. p. 415). I have watched the radiant closely without ever being able to detect the slightest change in its apparent place. The shower commences on October 8, possibly on October 5, and continues until the 29th, but I have only seen it sufficiently well to determine good radiants from October 8 to 24. I have re-examined my observations of this shower in and since 1874, and reprojected many of the meteors registered from it. After correcting some clerical and printer's errors in previously published lists my radiants are as follows :—

Date.		Radiant.	Meteors.
1877	October 8	$91^\circ + 13^\circ\frac{1}{2}$	5
1887	12–13	91 +17	4
1879–87	14	91 +15	6
1879	15	93 +17	16
1887	15	91 +16	17
1877	16	91 +15	15
1877	17	93 +14	33
1884, &c.	17	92 +14	4
1887	17	90 +15	3
1877	18	92 +15	9
1887	19	$90\frac{1}{2} + 15\frac{1}{2}$	10
1877 & 90	19	90 +15	4
1876	17–21	88 +17	8
1874	18–21	90 +17	8
1879	20	93 +15	21
1887	20	$90 + 14\frac{1}{2}$	22
1887	21	92 +14	23
1878	22	91 +15	11
1887	24	91 +16	9
1874–90	October 8–24	91·1 + 15·3 (mean of 19)	228

Many other observers have seen this fine shower and accurately determined its radiant. I have selected the following results as undoubtedly representing the best observations :—

Date.		Radiant.	Meteors.	
		° °		
1869	Oct. 5–6	91 + 9	8	Tupman, G. L.
1869	10	90 +12	...	Tupman, G. L.
1893	10	91 +16	8	Corder, H.
1869	12	89 +16½	5	Tupman, G. L.
1869	13	88 +14	12	Tupman, G. L.
1888	13	90 +13½	6	Booth, D.
1869	15–16	89 +16	15	Tupman, G. L.
1895	16	91 +15	6	Corder, H.
1895	16–22	89 +13	10	Blakeley, E. R.
1876–9	16–22	90 +14	...	Corder, H.
1869	17	91 +18	...	Tupman, G. L.
1868	17–18	90 +17	32	Backhouse, T. W.
1892	17–23	87 +18	9	Corder, H.
1892	17–29	92 +15	...	Milligan, W. H.
...	17–31	93 +18	5	Heis, E.
...	17–Nov. 13	90 +15	...	Greg and Herschel
1864	18	90 +16	14	Herschel, A. S.
1867	18–20	90 +15	12	Herschel, A. S.
1863	18–21	94 +15	...	Schmidt, J. F. J.
1879	19	92 +15	8	Sawyer, E. F.
1868	19–21	88 +14	14	Wood, W. H.
1868	19–22	92 +18	...	Schmidt, J. F. J.
1867	19–27	92 +17	...	Schmidt, J. F. J.
1887	20	91½ +15	10	Booth, D.
1865	20	90 +15	19	Herschel, A. S.
1868	20–31	92 +18	64	Zezioli and Weiss (reduced by Denning)
1868	21	93 +15	31	Zezioli, G. (reduced by Schiaparelli)
1868	21	95 +18	29	Zezioli, G. (reduced by Denning)
1848–68	21	93 +18	36	Gruber, L.
1892	...	90 +17	...	Backhouse, T. W.
1848–95	Oct. 5–Nov. 13	90·8 + 15·5 (mean of 30)		

The mean position of these is very nearly identical with the mean derived from observations at Bristol. In the foregoing table I have included Lieut.-Col. Tupman's observation of 1869 October 5–6, though it is unusually early, and though the radiant is 6° south of the proper place. The shower, however, has been so distinctly visible on October 10 to Lieut.-Col. Tupman

and Mr. Corder, while I have myself remarked traces of it on October 8, that it seems fair to assume its visible opening for October 5.

It is evident that if the radiant of the *Orionids* moved eastwards at the rate of 1° per day (as suggested for ring-formed meteor-systems by the late Dr. Kleiber), its displacement would have been readily apparent. For example, had the radiant occupied the following places the observations must have shown it in the most conclusive manner:—

October	12	85° + 15°
	18	91 + 15
	24	97 + 15

for a difference of 12° in the position is very large, and could not possibly have escaped detection. I believe my own determinations of radiants are within 2° of probable error.

The motion, if any, of the radiant would be in increasing R.A., as above; but apart from the test afforded by the comparison of radiants, let us examine the point by selecting such meteor paths (observed at Bristol) as were not far from their centre, and had motions chiefly in declination. It will be seen by the following paths of *Orionids*, recorded from October 12 to 24, that they indicate no displacement whatever in the right ascension of the radiant.

		h m	Mag.	Path. From.	Path. To.
1887	October 12	12 19	4	90° + 25°	89° + 29½°
1887	15	14 33	3	91 + 25	91 + 29
1877	16	12 22	3	90 + 43	88 + 63
1877	16	12 39	1	91 + 8	91 + 5
1877	16	13 54	4	94 + 2	96 − 4
1877	17	14 20	5	91 + 20	90 + 25
1877	17	14 31	3	95 − 6	96 − 15
1877	17	14 37	4	91 − 3	90 − 10
1877	17	15 2	3	86 ± 0	83 − 7
1895	17	16 5	4	88 − 2	87 − 5
1877	18	17 0	4	86 + 10	83 + 7
1874	19	11 25	4	84 + 13	77 + 9
1887	19	13 9	2	91½ + 33	92 + 38½
1879	20	8 32	1	86½ + 22	79 + 29½
1887	20	11 45	4	83 + 25	79 + 29
1879	20	11 59	4	94½ + 22	96½ + 25
1887	20	15 5	4	90 + 66	90 + 74
1887	21	12 5	1	86 + 5½	83 + 1½
1887	21	12 35	3	86½ + 20	84 + 22½
1887	24	12 18	4	91½ + 35½	92 + 40½
1887	24	12 30	4	95½ + 36	97 + 43

The star *ν Orionis* (mag. $4\frac{1}{2}$) is close to the radiant of this shower, as the following comparison will show :—

Place of radiant from 19 observations at Bristol	$91^{\circ}\cdot1 + 15^{\circ}\cdot3$
Place of radiant from 30 observations by various observers ...	$90\cdot8 + 15\cdot5$
Place of *ν Orionis* (1896)	$90\cdot4 + 14\cdot8$

A careful comparison of all the radiants given in the two lists will not reveal any indication of displacement. Some of the positions included in the second list are not, however, of much utility in their bearing on this feature, as they depend upon several nights of observation. Between October 5 and 29 the radiant retains a constant position about 1° N.E. of *ν Orionis*. In confirmation of its place near this star Professor Herschel writes : "I had always found the radiant so exactly at *ν Orionis* or so very near to it that that star became synonymous to me with an R.A. and declination place for the shower-centre, and I used it thus, in October 1867, as a just equivalent to a coordinate position."

There are several other showers from the region of *Orion* in October. There is one at 86° + 8° (near *α Orionis*), another at 89° + 20° (near *χ Orionis*), very definitely visible in September as well as in October, a third at 97 + 15 (near *γ Geminorum*), and a fourth at 107° + 12° (near *β Canis Minoris*). The one near *γ Geminorum* has been detected by several observers independently, as follows :—

Date.		Radiant.	Meteors.	
1869	Oct. 14	$97^{\circ} + 10^{\circ}$	9	Tupman
1879	20	97 + 11	5	Denning
1892	17–23	96 + 18 99 + 15 98 + 11	22	Corder { apparently a uniform radiant
1871	21	98 + 16	6	{ Miss I. Herschel Miss J. Herschel
1868	21	96 + 13	...	Zezioli
1871	21–23	97 + 15	13	Backhouse
1875	21–23	96 + 17	9	Backhouse
1893	22	97 + 19	4	Corder
1895	23–27	$97 + 17\frac{1}{2}$	15	Corder
1892	...	98 + 18	5	Backhouse
1894	Oct.–Nov.	97 + 18	5	Corder

The mean is at 97°·1 + 15°·2, and 6° E. of the *Orionid* centre. The radiant in *Canis Minor* (N.W. borders) is also very distinct,

and about 10° E. of the γ *Geminids*. The following are five observations of it :—

Date.		Radiant.	Meteors.	
		° °		
1869	Oct. 8	107 + 12	...	Tupman
1877	8–19	103 + 12	22	Denning
1879	15–20	106 + 12	5	Denning
	...	110 + 14	9	Corder
	18–27	108 + 12	...	Schmidt

The mean is at 106°·8 + 12°·4 and about 5° N.W. of β *Canis Minoris*.

There is another active shower at this epoch about 10° N. of this and near δ *Geminorum*. These several displays require further investigation, with special regard to the positions of their radiants. As to the γ *Geminids* (97° + 15°) I cannot quite understand this shower, as I only noticed it on one occasion (in 1879) and then from a position 4° S. of the mean place of the radiant as given by other observers. It is highly probable that many of the true *Orionids* are implicated in producing it, but it cannot be altogether set aside, the observations being too plentiful and corroborating one another in a way not to be disregarded. γ *Geminorum*, which is close to this radiant, is the brightest star a little east of the *Orionid* centre, and we should naturally expect that, in some cases, the observed tracks of *Orionids* would be estimated as directed precisely from that star, though really emanating from a point 6° west. This might sometimes have led the true *Orionid* radiant to be placed a little too far east and near γ *Geminorum*, but the point is one to be cleared up by further observations.

Bristol: 1895 *October* 30.

Observations of Perrine's Comet (c 1895) *made with the Altazimuth at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

These observations were made and reduced in a similar manner to those of the Moon with this instrument—viz. transits were taken by the galvanic method over the vertical and horizontal wires for observations of azimuth and zenith distance respectively, and the microscopes and levels were read. A double observation of *Regulus* was obtained on each day to determine the instrumental adjustments.

The following are the individual observations of azimuth and zenith distance :—

G.M.T.				Observed Azimuth.			G.M.T.				Observed Zenith Dist.		
d	h	m	s	°	′	″	d	h	m	s	°	′	″
1895 Dec. 6	18	7	8	304	19	0·7	Dec. 6	18	23	43	82	1	56·0
	18	21	5	307	11	47·1		18	36	56	80	27	14·1
	18	33	34	309	48	41·4		18	49	41	78	59	41·8
7	18	48	27	312	39	54·8	7	18	50	36	80	55	55·3

The above mean times are uncorrected for aberration. The observations are corrected for collimation, level, refraction, and parallax. In computing the latter, log Δ has been taken as 9·9680 on December 6, and 9·9547 on December 7, these values being interpolated from Professor Lamp's ephemeris in *Astr. Nachr.* 3,320, the corrections applied being 9″·4, 9″·4, 9″·3, 9″·7 respectively.

The aberration times were computed with the same value of log Δ, and found to be $7^m\ 42^s$ and $7^m\ 28^s$ on the two days. The tabular R.A. and N.P.D. were computed from Professor Lamp's ephemeris with third differences, after applying these corrections to the above mean times. The tabular azimuths and zenith distances were then computed for each observation, and the deduced apparent errors of the tabular places are as follows :—

G.M.T.					Tabular Azimuth—Observed Azimuth.	G.M.T.					Tabular Z.D.—Observed Z.D.
	d	h	m	s	″		d	h	m	s	″
1895 Dec.	6	18	7	8	−40·3	Dec.	6	18	23	43	+66·7
		18	21	5	−41·2			18	36	56	+71·0
		18	33	34	−38·0			18	49	41	+65·0
	7	18	48	27	−61·1		7	18	50	36	+98·7

The following errors of tabular R.A. and N.P.D. were then deduced :—

	Error of Tab. R.A.	Error of Tab. N.P.D.
	s	″
Dec. 6	+4·78	+38·5
7	+7·00	+57·0

Now the tabular R.A. and N.P.D. at the means of the times are as follows :—

G.M.T. (Uncorrected for Aberrn.)					Tab. R.A.			Tab. N.P.D.		
	d	h	m	s	h	m	s	°	′	″
1895 Dec.	6	18	28	41	15	4	32·27	105	37	43·7
	7	18	49	31	15	13	52·94	107	17	55·0

Whence are deduced the following observed R.A. and N.P.D. :—

G.M.T. (Uncorrected for Aberrn.)					Apparent R.A.			Apparent N.P.D.		
	d	h	m	s	h	m	s	°	′	″
Dec.	6	18	28	41	15	4	27·49	105	37	5·2
	7	18	49	31	15	13	45·94	107	16	58·0

The comet was very bright, and was observed in an illuminated field. On December 6 a distinct tail was seen pointing westward from the nucleus. The comet was looked for on several other mornings, but, owing to clouds, no other observations were obtained.

The observers on December 6 and 7 were Mr. Crommelin and Mr. Hollis respectively.

Royal Observatory, Greenwich :
1895 *December* 13.

Observations of Comets Encke, 1894, and Swift, 1895 August 20, at the Radcliffe Observatory, Oxford.

(*Communicated by E. J. Stone, Esq., M.A., F.R.S., Radcliffe Observer.*)

The following comet observations were made with the 10-inch Barclay Equatorial, using the ring-micrometer, with power 100.

Date.	G.M.T.	Local Sidereal Time.	Observer.	Comet *minus* Star (corrected for Refraction only). R.A.	N.P.D.	No. of Comps.	Apparent R.A. of Comet.	Parallax in R.A. p.	Log $(p \times \Delta)$.	Apparent N.P.D. of Comet.	Parallax in N.P.D. q.	Log $(q \times \Delta)$.	Ref.
				Comet Encke, 1894.									
1895.	h m s	h m s		m s	′ ″		h m s	s		° ′ ″	″		
Jan. 18	5 47 32	1 34 0	W.	−0 21·83	+2 14·6	11	21 55 57·92	+0·43	9·4733	91 40 21·5	10·2	0·8447	(*a*)
21	6 10 36	2 8 58	W.	−1 49·77	+2 34·9	3	21 47 18·24	+0·51	9·5220	93 32 16·5	10·7	0·8471	(*b*)
23	5 58 8	2 4 21	R.	−2 0·30	−0 4·4	4	21 39 54·13	+0·52	9·5254	95 5 41·2	11·0	0·8497	(*c*)
25	5 52 41	2 6 47	R.	−3 48·23	+6 3·5	3	21 30 59·01	+0·55	9·5357	96 56 53·3	11·3	0·8508	(*d*)
				Comet Swift, 1895 *August* 20.									
Aug. 24	12 5 15	22 12 15	R.	−6 20·85	+0 59·1	6	0 36 28·91	−0·40	9·3346	84 8 52·7	11·9	0·8074	(*e*)
24	12 14 1	22 21 3	R.	−7 47·46	−0 39·9	5	0 36 29·97	−0·38	9·3108	84 8 53·8	11·8	0·8064	(*f*)
28	11 21 56	21 44 35	R.	+0 19·16	+5 55·1	7	0 45 7·92	−0·49	9·4154	83 56 16·7	12·2	0·8001	(*g*)
28	12 8 36	22 31 22	R.	−2 5·98	+2 25·1	7	0 45 11·72	−0·38	9·3064	83 56 21·4	12·0	0·8050	(*h*)
Sept. 18	11 2 16	22 47 39	R.	+1 53·11	+0 24·3	8	1 16 13·79	−0·82	9·3429	84 23 23·3	23·9	0·8090	(*i*)
20	11 29 21	23 22 42	R.	−0 15·69	+7 32·1	17	1 17 52·84	−0·65	9·2472	84 32 4·8	23·6	0·8073	(*j*)
25	10 48 10	23 1 7	R.	+0 15·01	+0 43·0	13	1 21 11·45	−0·56	9·3230	84 54 21·9	17·2	·8114	(*k*)

Date.	G.M.T.	Local Sidereal Time.	Observer.	Comet *minus* Star (corrected for Refraction only). R.A.	N.P.D.	No. of Comps.	Apparent R.A. of Comet.	Parallax in R.A. p.	Log $(p \times \Delta)$.	Apparent N.P.D. of Comet.	Parallax in N.P.D. q.	Log $(q \times \Delta)$.	Ref.
1895.	h m s	h m s		m s	′ ″		h m s	s		° ′ ″	″		
27	12 32 0	0 53 7	R.	+2 29·55	−0 46·4	6	1 22 14·88	−0·20	8·8916	85 4 18·3	16·7	0·8074	(*l*)
Oct. 17	9 18 50	22 58 16	R.	−0 38·87	−4 58·6	6	1 26 39·97	−0·47	9·3438	86 21 42·2	14·0	0·8205	(*m*)
17	9 41 27	23 20 57	R.	−0 28·29	+4 57·9	6	1 26 40·44	−0·40	9·2805	86 21 54·2	13·9	0·8191	(*n*)
24	10 21 20	0 28 33	R.	−1 27·77	+6 35·9	8	1 27 23·39	−0·18	8·9678	86 33 8·2	12·7	0·8177	(*o*)

Observers' Remarks.

(*a*) The comet was faint when first observed owing to twilight. There is no tail, but a coma with brightening slightly following the centre of coma. The noises from bells, trains, and street are troublesome. (*b*) The comet is brighter than on January 18; a nucleus can be seen by gazing some time, but was of little use in observing: as before, the centre of the patch was taken. The objects were very low, and definition poor. Heavy clouds, with occasional breaks, drifted over during the observations of this evening. The above set was obtained in a break, and through trees. (*c*) Wind gusty this evening. The nucleus of comet is a diffused disc of the 9 or 10 magnitude, and follows the centre of the nebulosity. The image of the star is bright, but not well defined at times; objects low. (*d*) Difficult observations, some through trees. Comet, which is visible in strong twilight, is a diffused mass; centre observed. (*e* and *f*) The diameter of the coma surrounding the condensation is, approximately, 2′; it is an extremely faint, nebulous object. Observations difficult; guesswork at times. (*g* and *h*) There is no apparent change in the comet since August 24; the nebulous haze, with slight condensation, is extremely faint. Observations made with difficulty. (*i*) The faint nucleus is enveloped in a feeble coma which can be traced over a diameter of 3′. Sky unusually clear till midnight. (*j*) Comet extremely feeble, with a condensation. During the earlier comparisons to-night a star of about the same brightness as the nucleus (14 mag.) preceded, very closely, within the coma: this increased the difficulty of observation. (*k*) The star selected for comparison (mag. $9\frac{1}{2}$) is the brightest in the vicinity, but it is inconveniently close to the comet. There is no appreciable change in the form of the comet's coma and condensation; but the comet seems brighter than on any previous night. The sky is very clear above the ground fog. (*l*) The presence of a bright star in the field of view increased the difficulty of seeing the comet, which was very faint. (*m* and *n*) A star (mag. $10\frac{1}{2}$ or 11) followed the comet, say 3^s; the close proximity of this star made the observation very difficult, the comet being sometimes lost in the glare of the star. (*o*) The comet is a small faint haze without any perceptible nucleus; the centre observed as nearly as possible. Very difficult observations. Sky very clear.

Observers: W., Mr. W. Wickham; R., Mr. W. H. Robinson.

Assumed Places of Comparison Stars.

Ref.	Mean R.A.	Reduction to Apparent R.A.	Mean N.P.D.	Reduction to Apparent N.P.D.	Authority.
	h m s	s	° ′ ″	″	
(*a*)	21 56 20·55	−0·80	91 38 0·0	+ 6·9	Gould 30140.
(*b*)	21 49 8·81	−0·80	93 29 33·8	+ 7·7	Gould 29971.
(*c*)	21 41 55·23	−0·80	95 5 37·3	+ 8·3	Radcliffe, 1890, 5875.
(*d*)	21 34 48·03	−0·79	96 50 41·0	+ 8·8	Mean of Lamont 29127 and Schjellerup 8788.
(*e*)	0 42 46·50	+3·26	84 8 16·1	−22·5	Radcliffe transit-circle observations, 1895.
(*f*)	0 44 14·17	+3·26	84 9 56·3	−22·5	Radcliffe transit-circle observations, 1895.
(*g*)	0 44 45·42	+3·34	83 50 44·7	−23·1	Radcliffe transit-circle observations, 1895.
(*h*)	0 47 14·37	+3·33	83 54 19·4	−23·1	Radcliffe transit-circle observations, 1895.
(*i*)	1 14 17·03	+3·65	84 23 24·8	−25·9	Radcliffe transit-circle observations, 1895.
(*j*)	1 18 4·80	+3·73	84 24 58·8	−26·1	Radcliffe transit-circle observation, 1895.
(*k*)	1 20 52·69	+3 75	84 54 5·4	−26·5	Radcliffe transit-circle observations, 1895.
(*l*)	1 19 41·55	+3·78	85 5 31·3	−26·6	Albany, A.G., 392.
(*m*)	1 27 14·86	+3·98	86 27 8·1	−27·3	Albany, A.G., 424.
(*n*)	1 27 4·75	+3·98	86 17 23·6	−27·3	Albany, A.G., 423.
(*o*)	1 28 47·13	+4·03	86 26 59·6	−27·3	Albany, A.G., 440.

In the computation of the parallaxes the adopted value of the Sun's mean horizontal parallax is 8″·85 ; and the geocentric distances, Δ, are taken, for (*a*), (*b*), (*c*), (*d*) from the *Bulletin de l'Académie Impériale des Sciences de St.-Pétersbourg*, 1894 Novembre ; for (*e*), (*f*), (*g*), (*h*) from No. 3,308, for (*i*), (*j*) from No. 3,309, and for (*k*), (*l*), (*m*), (*n*), (*o*) from No. 3,310 of the *Astronomische Nachrichten*. The values of Δ given in these ephemerides for Comet Swift are discordant.

Radcliffe Observatory, Oxford : 1895 *December* 12.

Errata in Monthly Notices, Vol. LVI. No. 1.

Page 36, line 28, *for* them *read* then.
„ 38, line 3, *for* 1906 *read* 1900.